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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

10/6 Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. *1/- a Copy.*

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

This number is specially devoted to the ***Presidential Address*** delivered by ***Mr. A. P. Trotter*** at the Meeting of The Illuminating Engineering Society on December 18th, 1917, and some notes on events during the vacation, by the Hon. Secretary (Mr. L. Gaster).

The complete ***Index*** for the present volume (1917) is also enclosed.

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EDITORIAL.

Mr. Trotter's Presidential Address to The Illuminating Engineering Society.

On pp. 309-320 in this issue we reproduce Mr. Trotter's Presidential Address before the Illuminating Engineering Society on December 18th. It is just eight years since the late Professor Silvanus P. Thompson delivered his Inaugural Address, in which the field of work of the Society was ably summarised. Mr. Trotter's address forms a useful supplement to that presented by our first President. He deals in a characteristically lucid manner with the field of illuminating engineering as it now presents itself and the humour and irony occasionally revealed only serve to emphasise the enthusiasm that Mr. Trotter brings to bear upon his subject. The President, as all our readers know, was one of the earliest pioneers in the scientific study of illumination. His classic paper before the Institution of Civil Engineers in 1892 is rightly recorded as one of the first clear expositions of the distinction between the light yielded by a source, and its application, as illumination, to the practical problems of life. It is interesting to recall that Mr. Trotter presided at a meeting held at the Association of Engineers in Charge in 1907, when the project of forming an Illuminating

Engineering Society was first publicly introduced by the writer. It is our earnest hope that the Society will continue to benefit from his skill and experience for many years to come.

In the earlier portion of the address Mr. Trotter discusses the work of the Society, pointing out several respects in which it differs from many other bodies. While its field is essentially scientific it has a special function in uniting men engaged in different professions or concerned with various aspects of illumination ; not only do experts of various kinds find a common platform for the discussion of topics of common interest, but the co-operation of members of the general public, who are concerned with the uses of illumination rather than its technical aspects, is also sought. Passing on to the measurement of illumination, Mr. Trotter points out that, while essential to scientific study, they must be interpreted in relation to the impressions received by the eye, in accordance with the precept of Lambert, *solus oculus est judex*. The subject has also its historical side, and in forming our modern conceptions of the nomenclature of illuminating engineering, we can doubtless learn something, not only from early scientific workers like Lambert, but even from the ideas on the nature of light entertained by the ancient Greeks.

In the latter part of the address Mr. Trotter makes some illuminating references to current problems, such as the darkening of the streets. He gives an account, necessarily in very general terms, of a balloon trip undertaken for the authorities over London by night, in which the appearance of the shaded lights was observed. Mr. Trotter now voices what we believe may be regarded as the official view, that it is impracticable, by any method of screening the lights, to conceal completely a large city like London. The provision of a uniform illumination, and the avoidance of marked contrasts in brightness, appear to be the best form of camouflage. On the other hand, in the case of small towns and villages, particularly those on the coast, complete extinction of lights may be justified, and may be effective in concealing the neighbourhood and misleading hostile aircraft as to their position. In the future, therefore, it would be desirable to contrive means of diminishing or extinguishing the lights immediately the danger signal is received. If these points are borne in mind, and the inevitable effect on traffic in busy streets of extreme diminution in light is considered, the desirability of modifications such as those introduced by the authorities at the beginning of the present year will be appreciated. All of us fully recognise the necessity of meeting the requirements of the authorities on such points, and we have no doubt that in cases where experts like Mr. Trotter have been consulted the results have been beneficial. Our only regret is that the services of such experts were not more fully utilised at an early stage in the war, and that even at the present time they are not employed to the extent that seems desirable.

Mr. Trotter also refers to the work of the committees assisting the authorities, by experiments on flares, star-shells, parachute lights, and luminous paints used for gun-sights, and other purposes—facts which are now mentioned publicly, with the sanction of the authorities, for the first time. These special researches offer one interesting illustration of the many ramifications of illuminating engineering, and the opportunities for its application in war work at the present moment. They are instances of the fact remarked upon in our last number. Even the present circumstances have only served to divert, but not to check, the stream of investigation and research in the fascinating field of illumination.

Electric Power Supply in Great Britain.*

The Report recently issued by the Coal Conservation Sub-Committee of the Reconstruction Committee on the above subject will excite great general interest. In the introduction to the Report the Committee state that "it is scarcely possible to exaggerate the national importance of the problem of a technically sound system of electrical supply because it is essentially one with the problem of the industrial development of the country, which largely depends upon increasing the net output per head of the workers employed in the industries in which power can be used." A second important consideration is the economy in the use of coal which such a system may be expected to bring about.

That the present arrangements for electrical supply can hardly be described as "technically sound" will be generally conceded. They have developed individually according to the needs of each district, and have not been schemed out on any ordered plan. Electric supply is undertaken by over 600 authorities in as many separate districts, while in Greater London alone there are 70 supply authorities, with the additional disadvantage that the system of supply and the voltage vary according to the district served.

Small generating stations are admittedly uneconomical. It is therefore recommended that large super-plants should be established at suitable centres, where coal and water are available, and feeding into a main trunk distribution system laid down throughout the country. For this purpose the country should be divided into some 16 districts, throughout each of which there should be a standard periodicity and trunk main voltage.

It is estimated that the adoption of such a scheme would, in the near future, result in a saving of about 57,000,000 tons of coal per annum, and that this saving, if applied to the production of power, would make it possible to generate an additional 15,000,000 h.p. According to the figures presented in the Report, the output of coal in the United Kingdom in 1914 was 287,430,473 tons, on which 189,092,369 tons were reserved for home consumption. The estimated saving thus amounts to nearly 30 per cent.

Consideration of the probable future development of British industries shows, however, that it is not so much by reducing our total coal consumption as by increasing our industrial output for a given coal consumption that progress will be made. The effect of the scheme upon industry and transport would be very considerable. The amount of power used in the United States per worker is estimated at 56 per cent. more than in the United Kingdom, while, if we eliminate trades in which the use of power is not convenient, and restrict ourselves to those where it *can* be used in large quantities, we should probably find that the power used per worker in the States is double what it is here.

The development of adequate electric power supply would do much to remedy this deficiency, and to make possible the starting of many industries which are dependent on an abundant supply of cheap electrical power, and have hitherto been undertaken mainly abroad.

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* Interim Report on Electric Power Supply in Great Britain, presented by the Coal Conservation Sub-Committee of the Reconstruction Committee of the Ministry of Reconstruction, Cd. 8880, 3d. net., published by H.M. Stationery Office, Imperial House, Kingsway, London, W.C 2.

While the Report naturally lays stress mainly on the question of the use of electric power in industry, and the conservation of our coal supplies, it should not be overlooked that the advantages of such a system of supply upon lighting would be equally great. With the better facilities for producing power, and the equalisation of load throughout the country, the cost of electric lighting should ultimately be considerably reduced, and it should also be possible to do away with, or at least considerably improve, the highly complex and varied systems of charging at present in vogue. The great advantage to the lamp industry of a standard voltage should also be borne in mind. Lamps would be greatly improved and prices reduced by standardisation in manufacture. The great variety of pressures prevailing at present is admittedly a drawback, since it interferes considerably with standardisation. From the consumer's standpoint it is likewise inconvenient, especially in the case of Government Departments and industrial concerns, which have branches in different districts, and must therefore order lamps of a special voltage for each. When a factory is transferred from one district to another, it may be found that all the existing lamps, motors, &c., cannot be used, owing to the difference in the pressure or system of supply.

On the other hand, we imagine that an absolutely uniform voltage throughout the country would also not be quite convenient to makers of electric lamps, for it is desirable to allow a small margin for variation in manufacture, so that lamps inadvertently made to work at too high an efficiency can be transferred to a district with a lower voltage, or *vice versa*.

In their concluding remarks, the Committee recommend the appointment of a Board of Electricity Commissioners, with full powers to deal with the electric supply situation throughout the country, the sites for the central generating stations to be selected at once and plans prepared for the construction of the necessary plant immediately after the war. In an Appendix several alternative schemes for taking over the existing concerns are presented, and suggestions are made on the question of public or joint ownership of local electric concerns. No doubt the various super-generating stations will be added by degrees, and there will therefore be ample opportunity to take advantage of any important new developments. The linking up of such stations in industrial areas will have the advantage that they can assist each other in the event of local overload or destruction by hostile action.

Finally, while we recognise that this is probably a matter outside the scope of the Committee's terms of reference, we think that the very important question of co-operation with the gas industry should not be overlooked. In his recent presidential address before the Institution of Electrical Engineers Mr. C. H. Wordingham emphasised the desirability of co-operation of this kind, adding that gas production should be an essential intermediary between the raw fuel and the live steam. The problem of electric power production is a vast one, but the supply of gas throughout the country is equally vital. In selecting the sites for the generating stations, therefore, and in the choice of plant, the possibility of working hand in hand with those concerned with the supply of gas, and the production of its valuable by-products should be carefully considered. It is essential to get the maximum value out of the coal, whether in the form of electricity, gas or the derivatives which will no doubt play a vastly more important part in the gas industry of the future.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

FIRST MEETING OF THE NINTH SESSION.

(Proceedings at the Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m. on Tuesday, December 18th, 1917.)

A MEETING of the Society took place as stated above on Tuesday, December 18th, the PRESIDENT (Mr. A. P. Trotter) being in the Chair.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the following names of applicants for membership :—

Captain A. C. TRENCH, R.E., Oatlands, Simla.
Mr. JAMES LOWE, Engineer to the Carlton and Ritz Hotels.

The names of applicants for membership read at previous meetings on February 20th and May 15th* were also read again, and these gentlemen were formally declared members of the Society.

The HON. SECRETARY then presented the customary account of events during the vacation (pp. 307-308), in which he referred to the loss the Society had sustained in the death of Mr. W. DUDDELL, and announced that in accordance with the arrangements entered into with the Institutions of Gas and Electrical Engineers, the Acting Presidents of these two institutions, Lord MOULTON and Mr. C. H. WORDINGHAM, had been nominated Vice-Presidents and Members of Council of the Society during their tenure of office Dr. CHARLES CARPENTER had also been nominated a Vice-President and had kindly consented to act on the Joint Committee on Illuminating Engineering under the Department of Scientific and Industrial Research.

Reference was made to the work of this committee, to the investigations being undertaken by the special committees carrying out experimental work for the Ministry of Munitions, and the participation of the Society in the work of the Safety-First Council.

The Hon. Secretary also mentioned several important movements such as those bearing on Industrial Reconstruction and the Organisation of Engineering Training which would be considered in relation to the work of the Society.

Mr. A. P. TROTTER then delivered his Presidential Address (see pp. 309-319), in the course of which he gave a masterly survey of the work of the Society, illustrating the very varied nature of the subjects which fell within its scope. He pointed out that the study of illumination, besides being experimental, had its philosophical side, and that measurements of illumination must be interpreted in relation to the effect of light on the eye.

The President next touched on a number of matters that had been the

* *Illum. Eng.*, Feb. 1917, p. 39; April 1917, p. 101.

subject of discussion before the Society, such as Street Lighting, Nomenclature and Units, and Standards of Light, in connection with which the Society had found it desirable to co-operate with cognate institutions. Reference was made to the recently appointed Joint Committee on Illuminating Engineering, under the Department of Scientific and Industrial Research.

Turning to matters of special topical interest, the PRESIDENT remarked that the methods of street-darkening were of great interest to the Society, and gave a brief but very instructive account of some of his investigations on this point.

Reference was also made to several special investigations which the Society was undertaking for the authorities, such as tests on star-shells, flares and parachute lights, for which a special photometer had been designed. At the same time investigations were being made on the luminous radio-active paints employed for gun-sights and other special purposes.

Finally, the President referred to some of the chief physiological aspects of illumination, and concluded by expressing his conviction that a great field of usefulness lay open to the Society in the future.

Mr. F. W. GOODENOUGH (Chairman of Council) proposed a vote of thanks to Mr. Trotter for his address, and said that the Society must congratulate itself on having for its President one who had such a long and distinguished relation to illumination, and had done so much pioneering work in this subject. His address had been a masterly survey of the work of the Society, and they must all recognise how wide was the field covered therein. The need for closer relations between science and industry was now widely recognised, and the Illuminating Engineering Society was peculiarly fitted to promote this connection within its own field of work. It gave him great pleasure to propose the vote of thanks to Mr. Trotter, and he felt sure that the Society would prosper under his presidency.

Lieut.-Commander HAYDN T. HARRISON, who seconded the vote of thanks, said that he had long looked forward to the time when Mr. Trotter would assume the Presidency. He regarded Mr. Trotter's well-known paper before the Institution of Civil Engineers in 1892 as one of the first to emphasise the scientific side of illumination, and to draw the distinction between the emission of light at the source, and the resultant effect in the form of illumination.

Mr. Trotter had been honourably connected with much of the early pioneering work on the measurement of illumination, and in his Address he had remarked on the necessity for interpreting photometric results in relation to the impressions received by the eye. At the same time, they all knew that the eye was a most easily deceived organ, and required the aid of the photometer to correct its judgments. He was very glad to associate himself with Mr. Goodenough in proposing a vote of thanks to Mr. Trotter for his address.

Mr. GOODENOUGH having been called away at this point, the vote of thanks was moved by the HON. SECRETARY, who recalled that it was just ten years ago that the preliminary meeting was held at the Association of Engineers-in-Charge, at which the conception of illuminating engineering was first publicly discussed in this country, and the proposition to form an illuminating engineering society was made. In the absence of Sir William Preece Mr. Trotter had kindly consented to preside at that meeting, and then and afterwards gave him every encouragement. He hoped that the Society would continue to benefit by his knowledge and experience for many years to come.

The PRESIDENT, in acknowledging the vote of thanks, said that he would not have felt able to accept the position of president without the knowledge that he had the support of their enthusiastic Hon. Secretary and his assistant, Mr. Dow.

It was announced that the **next meeting** would take place at **5 p.m. on Tuesday, January 15th, 1918,** when a paper would be read by **Mr. L. Gaster** on "**Ten Years of Illuminating Engineering: Its Lessons and Future Prospects.**"

NOTES ON EVENTS DURING THE VACATION.

By L. GASTER, *Hon Secretary*

(Presented at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m. on Tuesday, Dec. 18th, 1917.)

IT is customary, at the first meeting of the session to give some account of progress during the vacation.

In accordance with the arrangement entered into with the Institutions of Gas and Electrical Engineers, the Presidents of these two institutions, namely, Lord Moulton and Mr. C. H. Wordingham, have kindly consented to become Vice-Presidents and Members of Council during their tenure of office. The Council had also nominated Dr. Charles Carpenter, who had kindly consented to act on the Joint Committee on Illuminating Engineering under the Department of Scientific and Industrial Research, a Vice-President of the Society. By the death of Mr. William Duddell, on November 4th, the Society has lost one of its distinguished Vice-Presidents. While chiefly known for his brilliant achievements in various branches of electrical technology Mr. Duddell took a keen interest in lighting, and, following the death of Mr. Edward Allen in 1915, became President of the National Illumination Commission in this country. In his early death science has lost one of its most brilliant representatives.

Among the younger members of the Society who have fallen in the war we note the name of Corporal Anderson, formerly associated with the Lancashire Electric Power Company.

Although no meetings are held during vacations, and in the present circumstances international gatherings to discuss lighting matters are naturally impracticable, the Society has nevertheless not been inactive during the last few months.

The Joint Committee working under the Department of Scientific and Industrial Research, and the special committees undertaking experimental work for the Ministry of Munitions, have been continuing their researches. In addition, suggestions have been submitted for the consideration of the authorities on such matters as economy in lighting in relation to fuel supply, lighting arrangements in connection with air-raid shelters, the desirability of obtaining fuller information and statistics relating to the effect of inadequate illumination in causing street accidents, and other matters.

Through its representatives the Society has also been participating in the work of the London Safety First Council, especially in regard to the relations between illumination and street safety. The programme of the Safety First Council has recently been extended to apply to industrial matters, and this will doubtless afford opportunities for further educational work regarding the importance of proper lighting of factories.

In another matter of public importance, the lighting conditions of cinema halls, the Society has also been consulted. It will be recalled that in a paper read by Dr. James Kerr before the Society on February 20th in the present year on "The Effect on the Eye of Varying Degrees of Brightness and Contrast," special reference was made to the lighting of cinema halls, as exemplifying very clearly the importance of avoiding glare and undue contrast. The attention of the Cinema Commission of Enquiry, a joint commission carrying on an investigation into the cinematograph industry generally, was drawn to this discussion, and two members of the Commission were present. An invitation was conveyed by them to the Society to co-operate with the Commission in regard

to matters of lighting, and the hon. secretary subsequently gave evidence pointing out various defects in lighting that needed to be guarded against, and suggesting the formation of a small joint committee to make further inquiries.

The members of the Commission in their Report recently issued,* endorsed the chief suggestions made and recommend the formation of a joint committee on the lines proposed. It is hoped that this suggestion will shortly be carried into effect and arrangements made for photometric tests of the illumination in a series of typical halls. In view of the influential and representative character of the Commission the Report will no doubt receive sympathetic consideration from the Authorities.

In view of the general recognition of the need for better organisation and extension of the nation's facilities for technical education it is interesting to observe that an important step has recently been taken in regard to technical optics. A special department of Glass Technology was established not long ago at Sheffield University, and the matter has likewise been receiving the attention of the Conjoint Board of Scientific Societies. In the recently issued Annual Report of this body reference is made to the formation of an Advisory and Administrative Committee, under the ægis of the Imperial College, on National Instruction in Technical Optics. Mr. F. J. Cheshire has been appointed Director of Studies in Technical Optics. It has been represented that such matters as photometry, the manufacture and testing of illuminating glassware, etc., should receive consideration in a complete scheme of Technical Optics, and the Director has kindly promised to bear this matter in mind.

It is also of interest to mention several matters which have been the subject of discussion in connection with industry and technical education generally, such as the proposals being made on Industrial Reconstruction and the Organisation of Engineering Training, which will receive due consideration in their relation to the work of our Society.

* *Illum. Eng.*, September, 1917, pp. 233, 234.

Turning next to activities in connection with illumination in other parts of the world we learn that the formation of an Illuminating Engineering Society is contemplated in Japan and preliminary steps have been taken to express the cordial desire for co-operation with our own Society. It is also stated that the Electrotechnical Section of the Russian Technical Society is forming a Standing Committee on Illumination, in which members of various scientific and technical societies will take part.

In the United States the usual Annual Convention has been cancelled on account of the war, but arrangements have been made for the circulation of papers and their discussion by correspondence. The series of lectures arranged by the Council of the American Illuminating Engineering Society on "Illuminating Engineering Practice," for delivery at the University of Pennsylvania, has been issued in volume form.

With the entry of the United States into the War the Illuminating Engineering Society in that country has been afforded several opportunities of rendering useful service to the Government. A National Committee on Lighting has been appointed by Mr. Samuel Gompers, Chairman of the Committee on Labour, of the Advisory Commission of the Council of National Defence. It will deal generally with the lighting of all factories, mills, munition plants, arsenals, etc., engaged on war work, from the standpoints of preservation of health, diminution of accidents, improved quality and output of work, and protection of property and persons.

Three new committees have also beed formed by the Society in the Uniten States to deal with (*a*) problems in the illumination of aviation cantonments, (*b*) standardizing lighting practice in industrial establishments, and (*c*) investigation on problems of visibility at sea.

The opportunities thus afforded to the American Illuminating Engineering Society to utilise the special knowledge of its members in connection with the war marks an important precedent which should be borne in mind by the authorities in this country.

ALEXANDER PELHAM TROTTER,

PRESIDENT OF

The Illuminating Engineering Society

(Founded in London 1909).

IT is with great pleasure that we record the acceptance of the Presidency of the Society by Mr. ALEXANDER PELHAM TROTTER, in succession to Sir William Bennett.

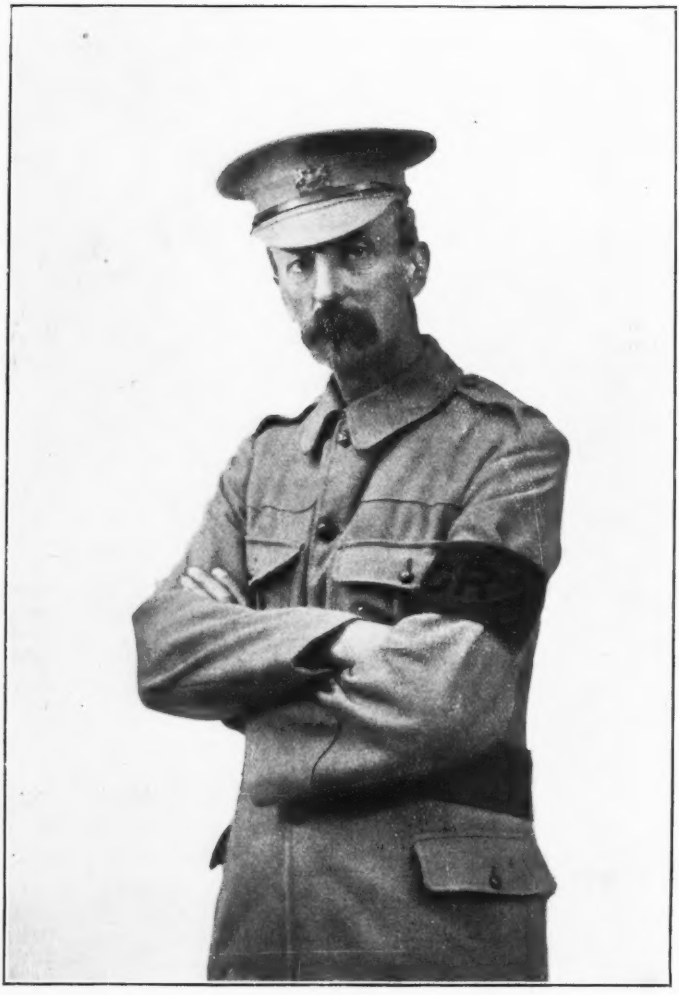
Born in 1857, educated at Harrow and at Cambridge under Clerk Maxwell, and trained as a mechanical engineer, he is now a partner in the firm of Handcock, Dykes and Trotter, Consulting Engineers, Westminster.

Mr. TROTTER has subsequently had a long and honourable connection with ILLUMINATING ENGINEERING. In association with Sir William Preece he was responsible for much pioneering work in illumination-photometry, and his early researches on prismatic illuminating glassware were equally in advance of the times.

He has been prominently identified with the work of the Society since its foundation, participating in the Joint Committees on School and Library Lighting, and on the Standard Specification for Street Lighting. He is Vice-Chairman of the National Illumination Commission.

Since the outbreak of war Mr. TROTTER has presided over a Committee of the Society, undertaking special experimental work for the Ministry of Munitions, and is also the Chairman of the Joint Committee on Illuminating Engineering, appointed under the Department of Scientific and Industrial Research.

The portrait of Mr. TROTTER on the reverse page represents him as Private 2474, C Company, Vth Battalion of the National Guard City of London Volunteer Regiment.



A. P. TROTTER

President of

The Illuminating Engineering Society

(Founded in London, 1909)

(As a private in the National Guard)

ADDRESS

By A. P. TROTTER, President.

(Address delivered at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m. on Tuesday, December 18th, 1917.)

IT sometimes happens that a man is called upon to undertake responsibilities in matters which have for many years been one of the relaxations from his daily work, to attempt a broad survey of a field in which hitherto his attention has been directed only where it has been attracted, and to treat seriously a subject which has been a hobby.

The Illuminating Engineer.

The name of the Society which has honoured me by electing me as its President was wisely chosen nine years ago. It is not the Society of Illuminating Engineers. At that time it is doubtful whether anybody was entitled to be called an illuminating engineer. To-day, an astonishing number of considerations must be studied by one who undertakes to give competent and impartial advice on the most appropriate and economical type of lighting for any given case, on the selection between electric light, gas, oil, or candles; whether the supply should be taken from the public mains or generated by a private plant; whether the gas to be used should be coal gas, petrol-air gas, or acetylene. And a yet more experienced man must be found who would claim to be able to carry out in detail the lighting of a palace, a railway terminus, a clothing factory, and a coal mine, in the best possible manner. Of these, the palace would perhaps be the most easy. We are proud to have such men amongst our members.

On a stocktaking occasion such as this, we may consider the general object of scientific societies, in order to see what we are doing, what we ought to do, and how we stand. In 1831 the British Association for the Advancement of Science was founded. At that date it is likely that science was not advancing as rapidly as might be, and the Association has to some extent achieved its purpose. But in the first decade of this century, and up to the outbreak of war, science was progressing by such leaps and bounds that some association or other agent appeared to be needed to stem the torrent of its advance. Even the war has but emptied college laboratories and diverted the attention of a very limited number of favoured men who have been permitted to apply their scientific knowledge and experience to naval and military operations.

The output of scientific work flows through four main channels, namely, the journals of scientific societies, the publication of books, the technical Press, and the work done in the private laboratories of manufacturers, which, if divulged at all, is published only through the Patent Office. Besides these, there is a rivulet of scientific work done for the love of it by men who do not care to write or to submit their writings to criticism.

The object of most scientific societies is the publication of the original work of its members and provision for discussion. In some cases, as at the Royal Institution, the communications are chiefly oral, and there is no discussion. At the older engineering institutions papers are written by specialists on subjects which they have made their own; these are submitted to the criticism of referees and of committees before acceptance, and are followed by discussions extending sometimes over several evenings. These papers and the reports of the discussions form the contents of Journals or Proceedings or Transactions. In some cases, as, for example, at the Royal Society, the papers are actively discussed, but no report of the discussion is ever published. In our Society we have often arranged for discussions without exacting heavy work from the

authors of papers. A very few terse statements are sufficient to provoke a good debate if the subject be well chosen. Where a scientific society can afford to print the papers in full, with their illustrations or diagrams, and to circulate copies several days before the meeting to members and visitors who are likely to contribute valuable remarks, a brief abstract is all that need be read, and to read the paper in full is a waste of time.

The multiplication of scientific societies is sometimes regretted, especially by older men. There were some 120 scientific and technical bodies before the war connected with engineering and various branches of physical science. Very few of these have been wound up, though some may be dormant. About 70 of these are societies at which papers are read and discussed; some 30 or so are associations of groups of men having some common interests in their professions or trades; and besides these there are social clubs and benevolent institutions. Excellent scientific work has been done, work that could not in any other way have been performed, by such comparatively small bodies as the Faraday, the Röntgen, and the Wireless Societies. These study the application of certain branches of physical science to a narrow subject or group of subjects. They ramify into particular lines of an exclusive character. The Institution of Civil Engineers, though not the oldest, is the premier body, and there are few branches of engineering to which it would not extend its dignified patronage. In 1892 it honoured that one for which our Society is founded by awarding its Telford Medal and Telford Premium to a paper on "The Distribution and Measurement of Illumination." A paper on illumination, whether theoretical or practical, read before one of the older engineering societies, would be addressed to an audience having more or less specialised interests. For example, that of Mr. Henry Fowler on "Lighting of Railway Premises," read before the Institution of Mechanical Engineers in 1906, or the paper by Lieut.-Commander Haydn Harrison on "Street Lighting," and the one by Messrs. S. L. Pearce and H. A. Ratcliff on "Recent Developments in Street Lighting in Manchester," read before the Institution of Electrical Engineers in 1910 and 1913 respectively.

The Extent of our Scope.

While it is true that advance can only be made by specialisation, and that the leading engineers of the day are specialists, the peculiar value of a Society such as ours is that the membership, and therefore the audiences, and hence the discussions, are representative of interests which not only widely differ, but are in some cases in spirited competition. It was predicted, when this Society was founded, that it contained elements so antagonistic, that it could not hold together. This prediction was wrong. The Society has been held together by the bond of science, and the fact that it has been so held, proves, if proof were needed, that it is essentially a scientific society. We are ready to hear what an engineer has to say about the distribution of gas or electric light to thousands of consumers, and we are equally prepared to listen to the criticism of a needlewoman on the lighting of her worktable. And since we are anxious to help architects, borough engineers, factory owners and inspectors, railway managers, searchlight operators, directors of museums and picture galleries, dyers, drapers and market salesmen, and five hundred other users of light, to use light economically, conveniently, usefully and efficiently, we seek their co-operation. We include makers, sellers, buyers, and, what is very important, the users.

In some industries manufacturers discuss designs and processes with each other, more often with the object of cheapening production than of any other advantage to the user. The user has no voice in the matter, and sometimes no choice. He is told more or less politely to "take it or leave it." Electric and gas fittings, and, to a smaller extent, oil lamps, are offered in sufficient variety to lead the purchaser to think that he uses some discernment of utility and judgment in taste when he makes a selection. But what really happens is that the best selling lines are pushed at him, and little or no attention is paid to his attempts to describe his wants. Our Society already includes members who have such wide interests, that its views

should be broad, and axe-grinding motives and cheese-paring policies should find no encouragement, but improvements in usefulness, excellence of quality, efficiency in operation, comfort, and artistic merit should be promoted and advanced.

"The Eye alone is the Judge."

When our members are called upon to advise on the lighting of some place or building, or to carry it out, they examine the conditions and consider the requirements; they recommend the most advantageous method and calculate the appropriate arrangement of lamps. If the job is one of some importance, a specification is drawn by a consulting engineer, tenders are invited, the best one is selected, a contract is made, and the work is carried out by a contractor. The results are checked by a photometer, and the client is told that the job is finished. Then he comes and judges whether the lighting is "good or bad" merely by using his eyes! This is one of the difficulties of our branch of engineering, and it warns us not to rely too much on rules and formulæ, and that we must interpret the readings of our photometers with discretion. The instrument may make a definite statement, but we must consider the context.

For this reason our Society seeks the assistance of that branch of the medical profession which cares for our eyes—that branch to which our distinguished retiring President, Sir William Bennett, belongs. We also look to physical science in connection with new sources of light, and to applied mathematics for methods of exact or of ready measurement. We are dependent on that difficult branch of chemistry, the art of glass-making, and we must be able clearly to explain to manufacturers what we want, and to see that we get it. Few, if any, scientific societies spread their activities over so wide a range and are in touch with so many different arts and industries. When a subject is considered in a truly scientific spirit, trade interests disappear, and professional competition is forgotten; for the muses, when they dance, hold one another by the hand.

Solus oculus est judex, wrote Lambert: The eye only is the judge. Even if an instrument should one day be invented, as Lambert hoped, which would indicate a quantity of light on a scale like a thermometer, our client's opinion of the lighting will not be materially influenced. Illuminating engineers must therefore give some attention to the subjective and to physiological interpretations of sense-impressions. These are generally of a complex character, and one of the first steps is to disentangle the factors, so that they may be dealt with one by one. Our Society has studied the question of glare. A good deal has been written and said about it. We all know that glare is the effect of a dazzling light; but that does not define glare, it only evades the definition by shifting it. It is much more easy to suggest means for avoiding glare than to define clearly what we mean by it. This is because it is a complex phenomenon arising from the relation of multiple sensations, while dazzle generally means too much light, which is a comparatively simple affair.

The Philosophical Side.

Those of us who give attention to the scientific side of our work should turn sometimes to the psychology of it: the empiric, experimental and observational psychology of course, not the metaphysical. "The psychological equation," observed *The Electrical Times* recently, "is entering more and more into these lighting problems." The rats seen by delirium tremens patients are subjective. An after image of a bright light is subjective according to some psychologists, but it is obviously due to and associated with an external stimulus. The nature of the peacock's feather or phosphene "seen" when we press the corner of our closed eye is not optical, the retina does not appear to be functionally concerned, but is due to a mechanical stimulus. Our sense-impressions are often misleading, and we allow ourselves deliberately to be deceived when we use a stereoscope. We seem to perceive extension in space and solidity of form when the object before us is flat and has no solidity.

The old Greek philosophers who did so much thinking and so little experimenting had queer ideas about light and vision. Empedokles, who died about 420 B.C., considered it necessary to

record the fact that darkness is not a real thing, but privation of light; and that the moon shines with reflected light, but he thought that the sun is the primary fire of the light of the sky reflected in a crystalline spheroid. Demokritus, who died about 370 B.C., held that vision was to be explained by emanations or exceedingly thin husks or films which were continually being detached or thrown off from the surface of bodies, and that they penetrated into the sense organs through fine passages or pores. We admit this in the case of taste and of smell. These ghost-like forms or images were called *eidola* (εἴδωλα), whence we have the word idol (a very different kind of image from those considered in optical books) and were supposed to be ever passing from the object to the moist and receptive surface of the eye straight into the mind. Aristotle, who died about 325 B.C., seems to have objected to some of the earlier theories. He hardly alludes to light and vision in *De Physica*, but there is some reason to suppose that a treatise by him on optics has been lost. More than two centuries later Lucretius, the scientific poet, discussed the theory at great length in his fourth book. He used the expression *simulacra quasi membranæ*, resemblances like films, peeled off from the upper surface of things, flying hither and thither on one side and the other through the air. *Simulacra* was also used for ghosts, and he goes on to explain how they terrify us in sleep. He also attempted to explain the action of curved mirrors, of the distance of the image behind a mirror, and why the theory does not work in the dark.

The schoolmen in the Middle Ages tried to follow Aristotle as closely as they could, but matter and form probably did not mean to them what they meant to Aristotle or to us. The *eidolon* was still used, but the expression had lost its materialistic signification. At the end of the 16th century men began to shake off dogmas of authority, to think for themselves, and to follow inductive lines of reasoning.

We may perhaps flatter ourselves that in our branch of applied optics we are not trammelled by fundamental theory, and that if the corpuscular hypothesis of light came back again into fashion next week to replace the undulatory theory, as the electron has pushed aside the elastic ether hypothesis which satisfied us in Maxwell's days, we should carry on with no change in our methods.

Nomenclature.

As knowledge advances, new terms become necessary to express new concepts. In our branch of science, new terms do not grow by accretion as in chemistry or zoology where each newly discovered substance or animal must receive a name. They multiply by fission, by the discovery that an idea, hitherto considered simple, is complex. Except in that branch of our work which deals with illuminants, our percepts remain much the same as those of Bouguer and Lambert in the middle of the 18th century. Nor did those pioneers discover new phenomena; their work was to describe systematically, in words and in mathematical symbols, visual impressions of ordinary experience.

The nomenclature of electrical terms has received the attention of the International Electrotechnical Commission. The British Committee appointed a nomenclature sub-committee of which I had the honour of being Chairman. That British Committee is now absorbed into the Engineering Standards Committee. It still includes nomenclature in its work, but if any action is to be taken on optical terms, representative of British practice, the co-operation of the Optical Society and of the Physical Society, and of the Institution of Gas Engineers, as well as our own Society, should be sought. Electrotechnical nomenclature has been settled on a wide basis; Germany took part in the work and materially impeded it by its suggestions.

Our Society has many foreign Corresponding Members, some of them in countries with which we are at war. It is quite possible to fight with an enemy whom we honour, but where there has been dishonour relations must be suspended. As scientific men we look forward to the time when scientific intercourse can be renewed. After the war we shall no doubt be prepared to treat individuals on their merits if it can be shown that there is absence of participa-

tion in the outrage to civilisation of which we complain. Meanwhile we must wait until those who were at one time associated with us realise and repudiate the perfidy and brutality of their countrymen.

Metaphysical discussions owe most of their perplexing entanglements to vagueness of terminology. Let us who study that branch of engineering and optics which deals with illumination at least understand each other as to the meaning which we agree to attach to the technical terms which we employ. The nomenclature of our subject has three aspects. One takes in the terms in ordinary use and includes some recognised but more rarely used expressions of a mathematical character. Another presents new terms or new relative orders or arrangements of terms. The third is the international outlook. It is fortunate that the vocabulary of illuminating engineering is not a large one. Most of our terms are borrowed from everyday language, such as brightness. We may have to restrict its application sometimes, by speaking of intrinsic brightness, and we must make up our minds whether it should be applied to a body which reflects light as well as to a self-luminous body. We must all agree what we mean by it and what we do not mean. Then again, we sometimes find it necessary to coin new terms, borrowing if possible a Latin word, such as Lumen, Albedo, or Lux. The man who first suggests such a term usually becomes the authority for its application. Lastly there is the correct translation of terms used in other countries, and the difficult question of logical sequence. An example occurs in the well-established use of candle and candlepower in English, and of the absence of any such expression as candlepower in French. The difficulty here is unusual in scientific nomenclature. The result is that while we have hitherto referred all photometric measurements to a more or less ideal candle, as the French used to refer to a *bougie* or to a *carcel*, we have accordingly derived our system of measurements from it. There is a proposal to use the lumen as the fundamental unit and to make the candle and candlepower secondary or derived quantities. This is the outcome of the clear philosophical logic of French science, and it has appealed to the academic type of mind which has recently made its appearance in America. Our Society has given some attention to the controversy which has arisen, and while we all admit that the lumen offers certain advantages in simplifying calculations by suppressing 4π, if the question of the fundamental unit or photometric quantity is to be pressed, that controversy will have to be continued.

Controversies.

We have had a great controversy also about street-lighting, and in their efforts to carry their views, members have done much useful work. The interesting paper on "The Mechanism of Colour Vision," which appeared in the last number of the Proceedings of the Physical Society of London might never have been written if the author had not been stimulated to controvert statements made in another "Theory of Colour Vision." The history of any subject will show that controversies are not ended by the arrival at a settlement which accords with the views of a majority who succeed in convincing a minority. A majority may thus override opposition and carry their views into action, but few persons who hold strong opinions give them up in consequence of argument or change them after hearing a debate.

In the Middle Ages logic was taught, not to help people to think and to argue, but to inquire how right thinking was done. At all times people thought straight by common sense who have never heard of premises and syllogisms. Logic asserted that if you start from true premises and employ exact methods of reasoning, you must arrive at a true conclusion. But the only way of ascertaining that the premises are true is to reduce them to self-evident axioms, and we are just as liable to err in this analytical direction as in the opposite synthetical process of building up an argument.

The difficulty in controversial matters is to avoid prejudices. These are not so much pre-judgments as the attachment of too great or of too small importance

to the ideas from which we start; a failure to distinguish between the essential and the accessory. Prejudices resemble internal stresses which cause heterogeneity in a body: troublesome when we are cautiously cutting our way through, and leading to unexpected cross-cleavages if we impetuously use force. Controversies may be said to arise from the polarisation of opinions. What was apparently uniform and continuous in character becomes divided into parts which differ strongly or antagonistically owing to the operation of some external agency. The depolariser required is called tact, a term for which there is no synonym. Changing the analogy again, interests which differ, move in parallel and harmonious flow without conflict as long as they go slowly. But when some accelerating force hurries things on, the condition of turbulent flow is reached, eddies are set up, and energy is uselessly expended. When the disturbing influence is removed, when the channel widens and the stream flows more slowly, controversies disappear and years afterwards it is difficult or impossible to recall the reasons for the raging.

Controversies have a habit of settling themselves. Minorities who bide their time instead of beating their heads against a wall, find that the views which were at one time so strongly opposed become adopted and blended with those of their former antagonists.

Cognate Institutions.

By reason of the wide range of our interests, we are in touch with several different scientific bodies from which we should derive help by offering them as much assistance as we can. Their function is to turn the mills of organisation, ours to supply a share of grist.

The National Illumination Committee of Great Britain.

This is a body affiliated to the International Commission on Illumination. It was constituted in 1914 by the co-operation of our Society with the Institution of Electrical Engineers, the Institution of Gas Engineers, and of the National Physical Laboratory, to carry on and to develop the work which had been begun by the original International Photometric Commission. The first Committee consisted of Messrs. Edward Allen, Frank Bailey, John Bond, W. J. A. Butterfield, Harold G. Colman, W. Duddell, Kenelm Edgecumbe, Leon Gaster, R. T. Glazebrook, F. W. Goodenough, Haydn T. Harrison, James Kerr, J. T. Morris, C. C. Paterson, S. P. Thompson, A. P. Trotter, and Robert Watson. The first three bodies have five members each and the last one, two members. Mr. Edward Allen was Chairman, Messrs. Duddell and Trotter Vice-Chairmen, Mr. Butterfield Secretary and Treasurer, Mr. Colman and Mr. Duddell Representatives of Great Britain on the Executive Committee of the International Commission, with Mr. Paterson a Secretary of that Commission. Mr. Edward Allen died in 1915, and Mr. Duddell succeeded him as Chairman, Mr. Bond replacing Mr. Duddell as Vice-Chairman. Mr. Jacques Abady succeeded Mr. Allen as a member of Committee. Mr. Butterfield desired to cease to act as Secretary and Treasurer, but no appointment has been made owing to the suspended action of the Committee during the war.

The Committee have given preliminary consideration to a uniform international method of rating and marking all sources of light, and to the nomenclature of photometric terms. When their work is resumed the Committee will doubtless co-operate with any other bodies, such as the Engineering Standards Committee, who are dealing with these subjects.

The Committee invited a number of laboratories and private individuals to investigate the relation between the height of the flame of a Hefner amyl-acetate lamp and its luminous intensity, with the object of settling the height at which it would give a light equal to one international standard candle, that is to say, to 1·111 times the light of the usual 40 mm. flame. Five reports were received, and these, together with an American paper and Liebenthal's original work, gave a mean result of 44·2 mm. for the height of the flame. Excluding two for special reasons, the remaining five are within a range of half a millimetre or about two per cent. of light. While this is a satisfactory performance for a lamp introduced so long ago as 1884, it is not

sufficient for scientific work of precision. The investigation should not be a difficult one. Corrections due to external conditions, to the quality of the amyl-acetate, and to personal equation in estimating the height of the flame, do not affect the result. The weak point probably is the difficulty of estimating the tip of the flame. The Committee have not yet issued a report on the investigation, and I have ventured to make this preliminary statement of the result without their authorisation.

Dr. E. Ott, of Zurich, a member of the original International Photometric Commission, sent to the British Committee a paper on the dependence of the light of the amyl-acetate lamp on atmospheric conditions, more especially on atmospheric pressure. The paper was translated by Mr. Butterfield, and was published in the technical Press. The results for atmospheric pressure agree with those of Butterfield, Haldane and Trotter, which were communicated to the meeting of the International Photometric Commission at Zurich in 1911. The difference for the effect of aqueous vapour is inconsiderable, and the effect of carbon dioxide was found by Dr. Ott to be smaller than by the British investigators. Dr. Ott is of opinion that a long series of investigations would still be required for a final settlement of these corrections, and hopes that a steadier and more easily managed unit of light will be found

The Engineering Standards Committee.

Reference has been made in connection with rating and marking of sources of light and with nomenclature, to the work of this Committee. Important work has been done for it on tests of electric glow-lamps, but the progress of recent years has rendered much of these obsolete. The published results did not disclose the names of the makers, but they suggested lines on which specifications might be drawn. This is intimately connected with the general question of rating. The proper rating of the output of a machine is of high importance, for many of the conditions of use have to be considered and defined. If the Engineering Standards Committee had done nothing but settle the question of rating of machinery they would have done valuable work. The rating of a lamp is of a much more simple character, and the question whether its output of light or its consumption of gas, oil or energy should be stated, is easily met by giving them both.

A Legal Standard of Light.

The unit of luminous intensity has been agreed upon by France, Great Britain and by the United States, and will probably be adopted by all civilised nations, and we call it the International Standard Candle. This is a rather unfortunate expression, for it makes a confusion between a unit and a standard. The unit may be embodied in a lamp burning pentane, amyl-acetate, or some other substance, or in an electric lamp, or as the average of a group of lamps, and may be one-tenth, or any other accurately known fraction of the light emitted by the lamp. The unit was at one time embodied in a certain kind of candle, subject to certain corrections. It was natural to call this the standard candle, and it seemed redundant to state that it emitted the unit of luminous intensity. Great confusion was made at one time in electrical science between units and standards, and we should be on our guard. We are all agreed upon the unit, which is derived from the old Parliamentary candle, and still bears the name, but the desideratum now is some actual apparatus which can be constructed to a definite specification, and, subject to working corrections, can be relied upon to emit unit luminous intensity.

A calorific test having been substituted for a luminous test of the quality of gas, it seems likely that the 10-candle Pentane Standard which has been for some years a standard of a very limited nature, will be dispossessed of the small legal dignity with which it was invested. It was only the standard for London and for the few other places which adopted it: for the brief authority of the Gas Referees is restricted to the Metropolis. Administrative changes will be made before a legal unit or standard of light is constituted, and perhaps we shall follow the action of other countries where science is not so despised by officialdom.

The Department of Scientific and Industrial Research.

It was briefly stated in our last Annual Report that a deputation of our members approached this Department in March, and submitted descriptions of the work of our Society and the directions in which it appeared that the operations of the Department might be extended to illuminating engineering. The result was that a Joint Committee of the Standing Committee on Engineering and on Glass and Optical Instruments, on Illuminating Engineering was constituted as follows. Engineering Standing Committee: Sir Maurice Fitzmaurice, Mr. J. S. Highfield. Glass Standing Committee: Sir Herbert Jackson, Prof. C. V. Boys. Co-opted members: Dr. C. Carpenter, Mr. F. W. Goodenough, Mr. L. Gaster, Capt. J. Herbert Parsons, Sir John Snell, and myself as Chairman.

This Department is one of an altogether new type. The officials are not chosen for proficiency in their knowledge of Chaucer, and they have not an instinctive dislike for science; on the contrary, they are most sympathetic. To have a good grasp or even practical experience of a subject is no longer a bar to membership of a committee. The Committee will not look upon the production of dreary official reports as the ultimate object of their labours. "Is all this important knowledge," wrote Florence Nightingale, "this strong, practical, good sense? . . . Is it to be buried in that most undisturbed grave of wise thought and useful information, a blue book, that most repulsive, unapproached, unapproachable place of sepulture?" The object of the Department is to cultivate, not to wither what it touches. It helps by inviting practical men to meet each other, and by finding funds for collection of information and for experiments. A certain amount of red tape cannot be avoided in any large organisation. There is no harm in red tape in its proper place. The objects of the Department and its proposed methods are so well known, or so easily ascertained by anybody who will expend threepence on (Cd. 8718) the last Report, that it is only necessary to consider how the science and industry of illuminating engineering can take advantage of the opportunities offered.

A list of 21 subjects for research was submitted for the consideration of the Committee, some industrial, some technological, and a few purely scientific. In the first place it did not appear that any scientific research having a direct bearing on the war can be conducted under this Department better than under the naval and military Departments which are already engaged on such work. It is not difficult to suggest scientific research in directions which may lead to useful commercial developments, but which require a greater expenditure of money than seems to be commensurate with the chance of success. It is worth while to make note of these, and to wait for the proper time to bring them forward. There are other researches on pure science from which no financial return seems likely. These might be carried out after the war, and I wish them every success, although I am rather doubtful whether endowed research in pure science can ever compare with inspired research.

On the industrial side there is more to be done. The Committee have inquired, in the first place, about goods which were imported from Germany or Austria before the war, and which were not made at all in this country. They have inquired about the manufacture of such goods, and the prices and qualities of the new home products. The valuable work of Sir Herbert Jackson on the manufacture of kinds of glass which have not hitherto been made in this country is placed at the disposal of the Committee, and when their recommendations are made as to the directions in which new branches of manufacture should be started, the Committee will be in a position to provide makers with samples, formulæ, and directions for making the goods. Some business organisation will be needed, since few glassmakers do a retail trade, and supply houses will have to be informed where these goods can be obtained.

Another branch of work in which the Committee may be able to render service is the specification of qualities and performances. Twenty or thirty years ago it was supposed that a sheet of ground glass or ordinary opal glass cut off from 40 to 60 per cent. of light, because this appeared to be the result when such a

sheet was interposed between a lamp and a photometer. Most of us know that in such a case the direct light falling on the photometer is no longer the only light to be measured, but also the light scattered in other directions by the translucent sheet. The public is entirely in the hands of the dealers in these matters. The ordinary buyer is quite unable to make the necessary measurements. The dealer probably knows nothing about it, and few manufacturers take the trouble to find out the figures, because they are never asked for them. The man who uses an opal shade knows that he gains something by doing so, namely a soft and agreeable appearance, compared with that of a naked, dazzling lamp. He is vaguely aware that he loses something in light, but he cannot tell or even guess approximately the gain or the loss. If he is entitled for some reason to a discount of 7½ per cent., and is offered only 5 per cent., the difference is quite clear to him, and he will take steps to get it. But whether he is losing 40 per cent. or only 10 per cent. by the absorption of his glassware is altogether unknown to him. At present it is nobody's business to look into these questions, and it appears to be one in which the Committee might act with advantage to the general public as well as to the lighting industry.

Street Darkening.

It is not possible at the present time to discuss freely the desirability of darkening the streets of towns during war time as a protection against air raids, or the degree or mode of darkening if this is considered advisable. While a frank discussion on this subject would probably remove many misunderstandings, it must remain for the present one of those in which we should submit to authority in the disciplined way to which the war has accustomed us. One of the difficulties has been the overlapping of the functions of different authorities, and the adjustment of their opinions. The subject of street darkening for war purposes was, of course, new to everybody, and it is not surprising that mistakes were made at first.

That considerable section of our Society which is interested in street lighting viewed with dismay in the earlier part of last winter, not only the suppression of all that work which had been so carefully studied in connection with the Standard Clauses for Street Lighting Specification, but also the alarming increase of accidents, especially in the streets of London.

The original anti-air defences of London were hurriedly thrust upon the Admiralty, and there was no time to go into new and difficult questions, and, of course, there was no experience to give warning of the accidents which did in fact result from over-darkening. The defence was afterwards transferred to the General Headquarters of the Home Forces at the Horse Guards, and the need for some modification soon became apparent. In November, 1916, I was sent for, and was asked to consider certain points which were put before me, and, with an officer of the London District, I inspected various parts of London in which the lamps had been obscured in various ways. In one street I measured an illumination considerably less than one-ten-thousandth of a foot-candle. I was asked to consider how much light could be allowed without revealing the topography of the district. In order to study this question more carefully, I was invited to make an aerial reconnaissance from a balloon at night.

It would, perhaps, be inexpedient at the present time to describe in detail what I saw. A stiff east wind was blowing and threatened to carry the two balloons which ascended to the west. They were therefore so ballasted that we shot up at once to 8,500 feet, where we found ourselves in the calm which sometimes lies between an east wind and a higher reverse current. There was plenty of time to study the lighting over a district of some five or six miles in diameter. The night was clear, cloudless and moonless. The most striking feature was the unmistakeable contrast between the black river and parks and the dim shimmer of the gloomy houses. Innumerable windows with drawn blinds gave the appearance of a granular film of brightness nearly equal to that which would have been produced by an illumination of 0·1 foot-candle. At that date, the streets were easily traceable by the patches of light below the screened lamps. The

sight was very beautiful, and it is sufficient to say that the authorities are of opinion that it is impossible to hide such a city as London by reducing the street-lighting. On the other hand, this does not apply to small towns, for, during a run of forty miles into the country, after the waning moon had risen, at the trailing height of 350 feet, it was impossible to distinguish between houses and hay-stacks. A small town and several villages were crossed without being seen. I can confidently assert that it is possible to obliterate a small town by extinguishing all street lamps and by careful shuttering and screening of the windows. But this screening must be intelligently carried out.

In the warfare of the future we must expect surprise attacks by large air squadrons. It will be necessary for engineers to consider the best means for control of street lighting, and, indeed, of all outdoor lighting, from the source, and provision for immediate extinction, when called upon by the military authorities to take this step. An independent street lighting system affords an excellent method of giving warning of an air-raid at night. There are very few instances of separate mains for street lighting, but a relay system for the control of electric lamps has been successfully tried and seems to be applicable for this purpose. It must be remembered that our coast towns, and indeed those near the coast, are visible from a considerable distance at night, in peace time. Enemy aircraft, deprived of the guiding lights of towns, have often hopelessly lost their way, and have scattered their bombs on open fields. Complete darkening of the whole country is undesirable for many reasons, even if it were possible, but a carefully considered reduction of lighting is in many cases well worth much inconvenience and some risk of accidents.

Without criticising the earlier or the present way in which the civil authorities have obscured the street lamps in London, it must be admitted that the coat of distemper on the glass panes of the lanterns gives a delightfully soft and agreeable effect. It contributes nothing to the uniformity of illumination which would disguise the topography of the district, and of course it is very uneconomical and inefficient. It is doubtful whether we shall ever return to the blatant glaring over-lighting of the years preceding the war; and when the lights are "turned up" again, the public will demand quality when they are offered quantity.

Future Developments.

The industrial and the consequential social changes and redistribution of wealth which may take place after the war do not appear to affect our Society in any particular way. We can point to a long-established and successful case of profit-sharing by one of the largest gas companies, and a recent and encouraging example in one of the smaller electric supply undertakings. Whatever changes of this kind may await us in the future, we are certain that scientific research has great things in store for us.

Distillation is said to have been discovered by the saturation of a fleece placed over a tub of wine. For many centuries the distiller sought one product only at a time. There are about 25 chief residual products of the distillation of coal, and to-day it is doubtful whether the word residual should be used at all, and which is the most important product to be aimed at. With my limited knowledge of the gas industry I can make no anticipations of its future. Coal gas and electric lighting will probably become by-products of chemical manufacture and of the supply of power respectively. In any case, however, we may confidently look for great advances in artificial lighting.

Fireworks and Fireflies.

Our first President, the late Professor Silvanus Thompson, in his Inaugural Presidential Address on the founding of our Society, referred to the youthfulness of that branch of engineering which we practise. It recalled, he said, illuminations on the proclamation of peace after the Crimean War. "Bengal lights and rockets. How the vision of them stands out in memory. But our Society has as little to do with fireworks as with fireflies. As little—and as much—for, after all, both of them are assuredly of some interest to the illuminating engineer."

He knew that the secret of the firefly is still hidden from us, but that if we knew it, if we knew how to produce the rapid vibrations which give the stimulus called light, without producing all the slow ones as well, as when we sound a high note with a finger instead of pressing all the keyboard at once, the mechanical equivalent of light would be as important as the mechanical equivalent of heat, and we should be able to produce light without heat. The quantity of energy which appears as useful light is about 2 per cent. of the energy radiated from an electric glowlamp; in the firefly it is about 96 or 97 per cent. In other words, if we could produce a highly efficient lamp, the light-generating output of a dynamo would be fifty times greater than now, and 45 lbs. of coal would do what a ton does to-day. The cost of lighting will not be reduced in anything like the same proportion. The cost of fuel is about one-tenth of the selling price of the light. The ordinary London householder pays 3d. to 6d. for his domestic lighting, which entailed a consumption of about 0·44d. of coal at pre-war prices.

Fireworks.

While so many engineers and scientific men have been eager to do something for the war, and so few have succeeded in finding any appreciation of their services, our Society must be content to have been allowed to carry out more than one investigation for which it was well fitted. Silvanus Thompson said that fireworks, as well as fireflies, were of some interest to the illuminating engineer. The star-shell, flares, and parachute lights which play so important a part in the war, are but fireworks. The chemist has used his skill to choose the most suitable compositions, and ingenuity has been expended in putting them up and in priming them; but in estimating the results, no further progress had been made beyond the stage of Lambert—the eye alone was the judge. Fortunately the right men in the right department were approached. It was recognised that photometric tests would be useful. Our Society offered to find men who would suggest methods, and give their time if necessary to carry out the work. A committee was accordingly formed; it conferred with the experts, who cordially placed their data and requirements before the members; a special photometer was at once discussed, designed, and made. At the present time nothing more can be said than that the instrument has fulfilled all expectations; it needs no manipulation whatever during observations, measurements may be taken over large ranges, and the behaviour of unsteady or flickering lights, can be recorded. The observations on a large number of samples, both of service patterns and of experimental kinds, were made by the committee during night meetings, and were reduced to candle-power-seconds per gram of composition, and it is hoped that the results have been useful.

Gun Sights.

Some five and twenty years ago it seemed likely that luminous paint would have many useful applications, but the results were disappointing. The preparation of one of the best kinds was kept secret and it was never properly placed on the market. Night operations of war have directed attention to this subject, and the old method of exciting zinc sulphide or other materials by light has given place to continuous stimulation by alpha rays of radium compounds. Dials of watches and compasses are well known, and luminous gun sights are no secret, but there are other applications which cannot be described at present. On these, a committee of our members has been working. Tiny tubes are used which are smaller and give less light than a glow worm, but in their preparation careful photometric measurements of considerable difficulty have been made, and valuable information has resulted from the research.

Physiology.

More work is wanted, or at all events more accessible literature is needed on the physiology of vision. The dioptrics of the eye are well understood; its normal, abnormal and pathological characteristics are the basis of opthalmic science. The theory of colour vision is still, perhaps, unsettled, though no one worker will admit it. The subject to which I

wish to refer is a purely quantitative one, and is the relation of light flux to visual perception. The range of the luminous stimulus to which the eye can respond is enormous. When we grope our way on so dark a night that objects are only just visible, the illumination is about one ten-thousandth of a foot-candle, or equal to that received from a candle at a distance of 100 feet. In summer sunshine we often have 5,000 foot-candles, and in clearer atmospheres than ours, 10,000 foot-candles are reached. The brightness of a furnace is even higher, and furnacemen judge the temperature by the colour.

By some marvellous organic control the eye so reacts that it is capable of estimating difference of tone and colour over a range of several thousand millions. The contraction of the pupil has very little to do with this regulation. It merely seems to take advantage of a greater stimulation to reduce spherical aberration. Over a large part of the enormous range Fechner's relation between stimulus difference and sensation difference holds good. There must be some intricate and delicate provision, perhaps, of a chemical change in the receptive portion of the eye, the retina, depending on saturation or exhaustion of material; or some inhibition of the transmissive portion, the optic nerve; or some compensatory reaction or opposing activity or fatigue in what Huxley called the sensificatory portion, the brain. The automatic adjustment of control which permits so sensitive an organ to accommodate itself to so great changes in the external stimulus, has its counterpart in other organs and functional mechanisms of the body, such as those which are concerned in breathing. If physiologists could tell us something about this quantitative control, it would help us in several ways.

Conclusion.

Some of our members have had to divert their attention from their ordinary work and to turn their energy in new directions. Many with reduced staffs have worked as they have never worked before. Some new enterprises have been laid aside for want of material, others have been stopped for lack of capital. Our working committees for the examination of library lighting, school lighting, and factory lighting have suspended their work for the time being. But our Society has not despaired, because we are convinced that a great field of usefulness lies open to us in the future, in the science and industry of illuminating engineering.

DEPARTMENTAL (HOME OFFICE) COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

We observe that Sir George Cave, in reply to a recent inquiry by Mr. Pemberton Billing in the House of Commons, said that the Departmental (Home Office) Committee on Lighting in Factories and Workshops presented a first Report in May, 1915. Owing to the war, the further inquiries contemplated by the Committee had to be suspended, and there had been no meetings of the Committee, no change in personnel, and no expense incurred in connection with it during the last two years. Good lighting in factories and workshops was of great importance to the health of workers and for the prevention of accidents, and had also a considerable effect on output. It was proposed that the inquiry should be resumed as soon as circumstances permitted.

This authoritative endorsement of the importance of good industrial lighting is very gratifying, and it may be hoped that it will not be long before circumstances permit the resumption of its inquiries by the Committee.

N.B.—The various items in the present number are included in the accompanying General Index for 1917.—Ed.

A FEW (out of over 100) TYPICAL REFERENCES to "The Illuminating Engineer" and the work of The Illuminating Engineering Society.

THE LANCET.—Light is one thing, but illumination is quite another; the first is the cause, the second the effect. We welcome the admirable efforts which the Illuminating Engineering Society is making to inculcate these principles.

BRITISH MEDICAL JOURNAL.—The flattering unction can be laid to the patriotic soul that at least in one respect Britain leads the world. Only a few years ago illuminating engineering might have been described as the Cinderella of industrial sciences. At present, thanks in a great measure to the impetus which has been given to the subject in this country . . . . it is claiming world-wide attention.

THE TIMES.—There is probably no other industry in which good lighting has more influence on the output of work than the printing trade. Two papers on the subject were read before the Illuminating Engineering Society last night.

THE STANDARD.—Fortunes are being lost through waste . . . . the loss to-day to many big institutions through non-apparent faults in artificial lighting must be enormous. . . . In view of the growing appreciation of the economies afforded by really scientific lighting a paper read before the Illuminating Engineering Society last week has timely interest.

ELECTRICIAN.—There is probably no subject whose principles are equally well understood and so frequently violated as the subject of illumination.

We earnestly hope that an effort will be made with the new lamps to display them both efficiently and effectively. . . . Speaking plainly, it means that the contractor must study illuminating engineering.

THE ELEKTROTECHNISCHE ZEITSCHRIFT (Berlin).—In view of the large number of treatises on the study of artificial illumination, the development of new sources of light and photometrical apparatus, etc., the appearance of a journal dealing concisely with the current literature of the subject will be hailed with satisfaction by engineers.

JOURNAL OF GASLIGHTING.—The work of the Illuminating Engineering Societies is proceeding in different countries: and gradually they are giving to their work an international significance. Where the technical bodies of both the gas and electric industries have not hitherto laboured, the Illuminating Engineering Societies have entered, and, we willingly agree, have been operating with good effect.

IL LAVORO.—England may be proud of the success of an idea originated in London and now spreading throughout the entire world. But a few years ago illuminating engineering was the Cinderella among the sciences. Thanks to the enthusiasm with which engineers and hygienists in England have taken the matter up, international attention is now being concentrated on this question.

THE MEDICAL OFFICER.—It cannot be too often insisted that the users of artificial light are themselves frequently to blame for results of which they complain.

The Illuminating Engineering Society, in a quiet, unobtrusive but none the less effective manner, has been doing excellent work.

THE IRONMONGER.—It must be known to all readers that very few acquaintances possess a room in their houses where it is possible to read in comfort. . . . A properly lighted room is as rare as good blotting-paper, pens, and ink outside a man's office. The private householder and the ratepayer . . . . suffer seriously in pocket from unfamiliarity with the best methods of developing useful and economical light.

THE BUILDER.—"The Illuminating Engineer" contains a number of communications on points connected with lighting, all of which are treated in a scientific spirit and give practical information. . . . "The Illuminating Engineer" is a publication which ought to be very useful to architects.

THE GLOBE.—The magazine should prove useful to a wide circle of readers and consumers, as well as lighting engineers.

CONTRACT JOURNAL.—The campaign carried on by the Illuminating Engineering Society (of which the journal is the official organ) is one that should be encouraged and helped by all those who value their eyesight, and also appreciate the economical and other advantages of light.

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